3. In NaOH-MeOH solution, however, BH_3 formed at the first stage being captured by NaOH, reduction of enamine with BH_3, was prevented at the second stage of the reaction and the dihydro compounds remained unchanged.

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Gas Chromatography of the Morphine Alkaloids and the Related Compounds

The microanalytical separation of the comparatively high molecular weight compounds such as steroids and alkaloids by gas chromatography has been very rapidly developed.[1~8]

In the present studies, the gas chromatographic analyses of forty three compounds, including the morphine alkaloids, sinomenine and its derivatives, were carried out in order to obtain the correlation between their structures and their retention times.

The compounds listed in the table gave single sharp peaks, consistent with the absence of decomposition, except for 8,14-dihydroxydihydrocodeinone (XXVIII).[*1] The relative retention times were calculated based on that of codeine (XIV) as a reference and the characteristics in the structure were illustrated comparing with dihydrodesoxycodeine D (II).

The retention times were increased as shown in the following cases: 1) opening of C_4~C_5 ether bridge, (II)~(IV), (VI)~(XX), (XXI)~(XXXVII), (XXX)~(XLII); 2) hydroxylation at C_{14}, (I)~(IX), (II)~(VI), (IV)~(XX), (XI)~(XXVI), (XIV)~(XXVII), (XVII)~(XXXII), (XXI)~(XXX), (XXXVII)~(XLII); 3) N-demethylation, (XIV)~(XIX), (XXX)~(XL); 4) acetylation of 14-hydroxy, (VI)~(X), (XXIX)~(XXXI), (XXX)~(XXXVI); 5) oxidation of the axial type hydroxy at C_6-position into the carbonyl,[*2] (XI)~(XXI), (XVI)~(XXIV), (XXVI)~(XXX). The retention times were decreased as observed in the following cases: 1) removal of the hydroxy or carbonyl group from C_6-position and the phenolic group from C_4-position, (III) or (XIV)~(I), (XI) or (XXI) or (XVII)~(II), (XXVI) or (XXX) or (XXXII)~(VI), (XXVII) or (XXIX)~(IX), (XXXVII)-(VII) (XXXVI)~(X); 2) methylation or ethylation of C_3- or C_4-phenolic group, (XXXVII)~(XXIV), (XLIII)~(XLI), (XXII)~(XVIII) or (XIV).

[*1] This showed also a single sharp peak with the same retention time as that of 14-hydroxycodeinone (XXIX) and it is expected that this compound is dehydrated into (XXIX) in the flash heating step.

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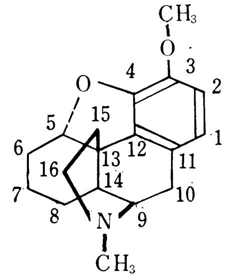
Horning,⁹⁾ Clayton¹⁰⁾ and Tsuda¹¹⁾ have shown that the axial 3-hydroxysteroids were eluted faster than their epimers. The following compounds of morphine series which contain C_6- or C_8-axial type hydroxyl groups, isocodeine (III), allopseudocodeine (VIII), dihydrocodeine (XI), dihydro-6α-thebainol methyl ether (XVI) and 14-hydroxydihydrocodeine (XXVI), always exihibited lower retention times than the corresponding epimeric compounds, codeine (XIV), pseudocodein (XV), dihydroisocodeine (XVII), dihydro-6β-thebainol methyl ether (XXIII) and 14-hydroxydihydroisocodeine (XXXII).



Dihydrodesoxycodeine D (II)

	Compound	R.R.T.	The characteritiscs
I	Desoxycodeine E	0.64	$\Delta_{7,8}$
II	Dihydrodesoxycodeine D	0.66	
III	Isocodeine	0.74	$\Delta_{7,8}$, $C_6\beta$-OH
IV	Tetrahydrodesoxycodeine	0.77	opening the ether ring, C_4-OH
V	Pseudocodeinone	0.80	$\Delta_{6,7}$, C_8=O
VI	14-Hydroxydihydrodesoxycodeine D	0.84	$C_{14}\beta$-OH
VII	Dihydrodesoxythebainone	0.86	opening the ether ring, C_6=O, C_4-desoxy
VIII	Allopseudocodeine	0.91	$\Delta_{6,7}$, $C_8\alpha$-OH
IX	14-Hydroxydesoxycodeine E	0.91	$\Delta_{7,8}$, $C_{14}\beta$-OH
X	14-Acetoxydihydrodesoxycodeine D	0.93	$C_{14}\beta$-OAc
XI	Dihydrocodeine	0.96	$C_6\alpha$-OH
XII	Neopine	0.97	$\Delta_{8,14}$, $C_6\alpha$-OH
XIII	Codeine methyl ether	0.98	$\Delta_{7,8}$, $C_6\alpha$-OCH_3
XIV	Codeine	1.00	$\Delta_{7,8}$, $C_6\alpha$-OH
XV	Pseudocodeine	1.03	$\Delta_{6,7}$, $C_8\beta$-OH
XVI	Dihydro-6α-thebainol methyl ether	1.07	opening the ether ring, C_4-OCH_3, $C_6\alpha$-OH
XVII	Dihydroisocodeine	1.07	$C_6\beta$-OH
XVIII	Dionine (ethyl morphine)	1.09	$\Delta_{7,8}$, C_3-OC_2H_5, $C_6\alpha$-OH
XIX	Norcodeine	1.09	$\Delta_{7,8}$, $C_6\alpha$-OH, N-H
XX	14-Hydroxytetrahydrodesoxycodeine	1.13	opening the ether ring, C_4-OH, $C_{14}\beta$-OH
XXI	Dihydrocodeinone	1.15	C_6=O
XXII	Morphine	1.17	$\Delta_{7,8}$, C_3-OH, $C_6\alpha$-OH
XXIII	Dihydro-6β-thebainol methyl ether	1.20	opening the ether ring, C_4-OCH_3, $C_6\beta$-OH
XXIV	Dihydrothebainone methyl ether	1.22	opening the ether ring, C_4-OCH_3, C_6=O
XXV	14-Hydroxydihydrodesoxycodeine C	1.30	opening the ether ring, $\Delta_{5,6}$, C_4-OH, $C_{14}\beta$-OH
XXVI	14-Hydroxydihydrocodeine	1.35	$C_6\alpha$-OH, $C_{14}\beta$-OH
XXVII	14-Hydroxycodeine	1.35	$\Delta_{7,8}$, $C_6\alpha$-OH, $C_{14}\beta$-OH
XXVIII	8,14-Dihydroxydihydrocodeinone	1.37	C_6=O, $C_8\beta$-OH, $C_{14}\beta$-OH
XXIX	14-Hydroxycodeinone	1.38	$\Delta_{7,8}$, C_6=O, $C_{14}\beta$-OH
XXX	14-Hydroxydihydrocodeinone	1.39	C_6=O, $C_{14}\beta$-OH
XXXI	14-Acetoxycodeinone	1.41	$\Delta_{7,8}$, C_6=O, $C_{14}\beta$-OAc
XXXII	14-Hydroxydihydroisocodeine	1.43	$C_6\beta$-OH, $C_{14}\beta$-OH
XXXIII	Thebaine	1.48	$\Delta_{6,7}$, $\Delta_{8,14}$, C_6-OCH_3
XXXIV	8-Methoxy-14-hydroxydihydrocodeinone	1.48	C_6=O, $C_8\beta$-OCH_3, $C_{14}\beta$--OH

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*2 The similar change of the equatorial type did not significantly effect the retention time, i.e. (XXII)∼(XXIV), (XVII)∼(XXI), (XXII)∼(XXX).

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XXXV	Dihydrothebainoneϕ	1.52	opening the ether ring, $\Delta_{5,6}$, $\Delta_{8,14}$, C_4-OH, C_6-OCH_3
XXXVI	14-Acetoxydihydrocodeinone	1.52	C_6=O, $C_{14}\beta$-OAc
XXXVII	Dihydrothebainone	1.61	opening the ether ring, C_4-OH, C_6=O
XXXVIII	N-Propalgyl-14-hydroxydihydronorcodeinone	1.69	C_6=O, $C_{14}\beta$-OH, N-$CH_2C{\equiv}CH$
XXXIX	Sinomenine methyl ether	1.87	antipode, opening the ether ring, $\Delta_{7,8}$, C_4-OCH_3 C_6=O, C_7-OCH_3
XL	14-Hydroxydihydronorcodeinone	1.91	C_6=O, $C_{14}\beta$-OH, N-H
XLI	Dihydrosinomenine	2.00	antipode, opening the ether ring, C_4-OH, C_6=O C_7-OCH_3
XLII	14-Hydroxydihydrothebainone	2.45	opening the ether ring, C_4-OH, C_6=O, C_{14}-β-OH
XLIII	Sinomenine	2.83	antipode, opening the ether ring, C_4-OH, C_6=O C_7-OCH_3, $\Delta_{7,8}$

Apparatus : Barber Colman Model 10, Argon ionization detector, 6 ft × 8 mm., 1% SE-30 on gas-chrom P (100～140 mesh)
Condition : Column temp. 185°, Cell temp. 160°, Flash heater temp. 280°, Argon pressure 2 kg./cm^2
Sample : 0.5～1% Me_2CO solution were used except in the case of morphine (XXII) in which 0.5% MeOH solution was used
Standard : Codeine = 4.71 min. = 1 R.R.T.

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Teflon Coated Support for Gas Chromatography at a Lower Temperature

The gas chromatographic analysis has no doubt been a very effective tool for chemists, but there is a narrow limitation of tailings which occur inevitably when the analysis is done at a lower temperature, with strongly polar substances and/or on the packings containing minor amount of stationary liquid (e.g. 0.1～10%).

Many attempts which have been done to reduce such tailings, can be classified as follows; a) use of new support. e.g. salts,[1] glass beads,[2] sea sand,[3] quartz. powder,[4] metal helices,[5] Tide[6] or Teflon powder,[7] b) improvement of firebrick or Celite, e.g.

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